constancy of specific characters. These, he showed, remained unaltered throughout great extents of time and space, and other slight structural characters endured through many geologic ages. Hence the value of cases where the association of characters is evidently in a transitional condition.

THE EMBRYOLOGY OF CHRYSOPA, AND ITS BEARINGS ON THE CLASSIFICATION OF THE NEUROPTERA.—BY A. S. PACKARD, JR., M.D.

IN a paper presented at the Burlington meeting of the Association in 1867, I gave a brief sketch of the embryology of Diplax, especially in the later stages. Those observations, with the far more carefully elaborated studies of Brandt* on Calopteryx, another member of the family Libellulidæ, have made us acquainted with the embryology of the type of one important division of Neuroptera, and now I have to offer a partial history of Chrysopa, the representative of another important division of the group. I did not observe the formation of the blastoderm, but the blastodermic skin ("amnion") of Chrysopa, is of the same structure as in Calopteryx. At the posterior end of the egg the round nucleated cells are crowded together in the same way as in Calopteryx. The primitive band is of the same general form, and floats in the yolk as in Calopteryx, but more as in Aspidiotus, though it rests more on the outside of the yolk than in those genera, and the end of the abdomen rests on the outside of the yolk, rather than rolled in within the yolk; but that the germ is an endoblast (so far as that condition has any special significance) is shown by the fact that the ventral side of the primitive band points inwards towards the centre of the yolk, as in the Libellulidæ, the Hemiptera, and some Coleoptera (Telephorus and Donacia) in contradistinction to the Phryganeidæ and the Poduræ (Isotoma) in which the germ or primitive band floats entirely on the outside of the yolk. After the procephalic lobes and rudiments of the appendages of the head and thorax have begun to develop, a second moult (visceral layer) of the blastoderm is made, which envelops the head and under side of the body much as in the Libellulidæ and Hemiptera. At this time the embryo is much like that of the last named insects. The germ does not revolve in the egg, as

*Beiträge zur Entwicklungsgeschichte der Libelluliden und Hemipteren. St. Petersburg. 1869.

in the Libellulidæ, but the head remains throughout embryonic life next the micropyle. At the next stage observed, the appendages of the limbs had appeared, the embryo being situated on the outside of the yolk, the end of the abdomen curved around on the opposite side of the yolk. At this time the inner or "visceral layer," forming a second moult of the blastoderm, envelops the germ, much as in the Libellulidæ, and Hemiptera, and Coleoptera (Donacia). It is evident that this *faltenblatt* of Weismann (or visceral layer of Brandt) is shed at a later stage than the "amnion" proper. This stage corresponds with that of Calopteryx figured by Brandt (Pl. 1. fig. 11). At this time the germ of Diplax and Calopteryx (Libellulidæ) floats within the yolk, but this difference I would regard as having no special importance, as in the Hemiptera the germ at the same stage of development rests on the outside of the yolk in Corixa, while in the Pediculina, according to Melnikow's researches, the germ floats within the yolk, and we shall see farther on that in the Curculionidæ (Attelabus) the germ rests on the outside of the yolk (ectoblast), while that of Telephorus is a decided endoblast, *i. e.*, floats in the interior of the yolk. After this period, the embryo of Chrysopa exactly corresponds to that of all the Libellulidæ whose development is known (Agrion, Calopteryx, Perithemis, and Diplax.)

The embryogeny of Chrysopa is identical, then, with that of the Libellulidæ. What becomes, therefore, of the distinction between the "Pseudoneuroptera" and "true" Neuroptera, insisted on by some of the leading entomologists, since Erichson's day? Never believing that the differences were great enough to separate the Linnæan Neuroptera into two independent orders or suborders (whichever we may choose to call them), I now ask if embryology does not give independent testimony as to the close alliance at least of the Libellulidæ and Hemerobidæ, even if we go no farther?

The only Coleoptera with whose development we are acquainted is Donacia, worked out more carefully by Melnikow than any one else. During this summer I have studied *Telephorus fraxini* and *Attelabus rhois* in nearly all their embryonic stages. They are developed in the same manner as in Donacia. There is a parietal ("amnion") and a visceral membrane in Attelabus; (it was not observed in Telephorus, though it doubtless exists), as in Donacia. In Attelabus, however, the primitive band rests on the outside of the yolk, while in Telephorus it floats in the yolk, and forms a

sigmoid band, extending back to the posterior pole of the egg. But after the rudiments of the limbs appear, the embryology of both genera accords with that of Donacia. I have found that the embryology of *Gastrophysa cœruleipennis* in its later stages also agrees with that of Donacia, (both being Chrysomelids.) A study of the development of *Nematus ventricosus*, shows us that its embryology accords with that of *Apis mellifica*. The formation of the blastoderm is as described by Bütschli in Apis,* and quite unlike that of the Formicidæ as studied by Ganin. It also agrees with that of the Diptera in most particulars.

There is indeed a remarkable uniformity in the mode of development of the Hexapoda, as much so perhaps as in the Crustacea (Malacostraca), and it is difficult to determine what embryological characters may be set down as distinguishing even the different suborders. These characters, whatever they may be, do not probably reside in the embryonal membranes, or in the relation of the primitive band to the yolk. Perhaps they will be found in the form of the advanced embryos. For example, we now know that the embryos of the Isopod Crustacea only differ from those of the Amphipods while in the egg by having the end of the abdomen bent over the back, while in the latter (Amphipods) it is curved beneath the body, as pointed out by Fritz Müller. The spiders and scorpions also pass through a similar course of development, and the Mites (Acarina) are developed in a manner either identical with the spiders in some genera, or more like the Hexapods in others. We know almost nothing of the embryology of the Myriapods, but Newport's observations on Julus indicate that it is developed in an entirely different mode from the Hexapoda or Arachnida, a remarkable feature being the persistence of the larva in its inner (?) embryonal membrane (*faltenblatt* of Weissmann) for many days after it is hatched.

There are, however, two modes of development in the Hexapoda, depending on the position of the primitive band in relation to the yolk. The Hymenoptera, Diptera, and certain Coleoptera (Curculionidæ), and the Phryganeidæ and Poduræ (Isotoma) are *ectoblasts*, † while the Hemiptera and certain Neuroptera (Libellulidæ

*Dr. O. Bütschli. Zur Entwicklungsgeschichte der Biene; Siebold and Kolliker's Zeitschrift, 1870. p. 519.

† I omit any reference to the Lepidoptera, which Dr. Dohrn regards as endoblasts but which I am inclined from some eggs (probably of an Arctian) I have studied to regard as developing like the Hymenoptera and Diptera.

and Hemerobidæ) are *endoblasts*, to use Dr. Dohrn's terms. On inquiring how far these two modes correspond to the degree of development of the insect on leaving the egg, and the degree of metamorphosis of the insect before becoming adult, it seems that the endoblasts occur in those ametabolous insects (Hemiptera and Neuroptera) with flattened, leptiform larvæ, and also in those Coleoptera with similar larvæ, as distinguished from the weevils, which have eruciform larvæ, *i. e.*, resembling the maggots of Diptera and Hymenoptera. The two modes of development, then, do not fully accord with the two different degrees of metamorphosis of insects, but more probably depends simply on the form of the larva when hatched. Now there are two forms of insectean larvæ which are pretty constant. One we may call *leptiform*, from its general resemblance to the larvæ of the mites (Leptus). The larvæ of all the Neuroptera, except those of the Phryganeidæ and Panorpidæ (which are cylindrical and resemble caterpillars), are more or less leptiform, *i. e.*, have a flattened or oval body, with large thoracic legs. Such are the larvæ of the Orthoptera and Hemiptera, and the Coleoptera (except the Curculionidæ; possibly the Cerambycidæ and Buprestidæ, which approach the maggot-like form of the larvæ of weevils). On the other hand, taking the caterpillar or bee larva with their cylindrical fleshy bodies, in most respects typical of the larval forms of the Hymenoptera, Lepidoptera and Diptera, as the type of the *eruciform* larva, we find that those insects with such larvæ are ectoblasts. (The Poduræ which, as in Isotoma, are ectoblasts, and are certainly leptiform when hatched, form an apparent exception.) Thus the two modes of development (ectoblastic or endoblastic) perhaps simply depend on the form of the insect when hatched, and its mode of life.

The leptiform larvæ of insects may be compared with the nauplius form of Crustacea, and in a much less degree the eruciform to the zoea form. The three higher suborders of insects may be compared to the Malacostraca with their zoeæ form larvæ, and the four lower suborders (Coleoptera, Hemiptera, Orthoptera and Neuroptera) with the Entomostraca,* in which certain forms, as in some Phyllopods, and Limulus, and the Trilobites, are hatched in a subzoea condition (corresponding to the eruciform larvæ among the Neuroptera and Coleoptera). The larvæ of the earliest insects

* The terms Malacostraca and Entomostraca are used for convenience, not that they are entirely natural divisions.

were probably leptiform, and the eruciform condition is consequently an acquired one, as suggested by Fritz Müller.* His suggestion, followed up by Brauer, that the insects have descended from some zoea does not seem of much value, as the leptiform larva more exactly parallels the nauplius of the lowest Entomostraca (Copepoda). We have already suggested that the Insects and Crustacea probably arose by two distinct lines of development from the worms, rather than that the Nauplius gave rise to the Insects, as Müller has suggested; an important reason for this view being that the three pairs of appendages of the Nauplius do not homologize with the distinct cephalic and three thoracic appendages of the Leptus.

The Organic Identity of the Albumen and Endopleura of all the Phanerogamæ.—By T. C. Hilgard, M. D.

All seeds of the flowering plants (the net-leaved, blade-leaved and the pine tribes) are collectively described as consisting of a *germ* or "embryo," enclosed within *two separate seed-coats.*

A great many seeds, like those of the mustard, nasturtium, buck-eye, bladder-nut, the ailanthus, sumach, china-tree, orange, camellia; the gum-pod ("gumbo"), hibiscus, the cocoa-bean, almond, pea and rose-tribes, the brazil-nut, walnut, chestnut; the cockle-bur, sun-flower and melon all conform to this description, and the natural tribes to which they belong form a connected region of the flowering plants generally speaking.

It is likewise understood that a great many seeds have their germ proper imbedded in a bulky, nutritive lump called the "*albumen*"; which thus forms the main bulk of the seed, *e. g.* of the ivory-nut, the date-kernel, the cocoa-nut, the pepper, paw-paw and nutmeg, and all the grains no less than the well known coffee-bean. In water, the latter will swell and protrude its stubble-like embryo out of one end of its horny, enveloping mass, or "*albumen.*"

It has, however, hitherto remained an unnoticed fact that all seeds which have *two* so-called seed-coats, are all alike *destitute of*

* "It is my opinion that the 'incomplete metamorphosis' of the Orthoptera is the primitive one, *inherited* from the original parents of all insects, and the 'complete metamorphosis' of the Coleoptera, Diptera, etc., a subsequently acquired one."—*Für Darwin.* Eng. Trans. p. 121.